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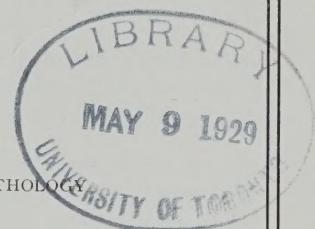
STUDIES IN POTATO DISEASES

THE BLACK LEG DISEASE
OF POTATOES

(*Bacillus phytophthorus* (Frank) Appel)

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THE BLACK LEG DISEASE OF POTATOES

(*Bacillus phytophthora* (Frank) Appel)

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Black leg is a destructive bacterial disease affecting many varieties of potatoes. It is widely prevalent and has been reported from all the provinces of Canada, nearly every state in the United States, as well as a number of the important potato-growing sections of Europe.

Early investigators of the disease reported cases where upwards of 50 per cent of the plants in a field were destroyed. At the present time, especially where control measures have been intelligently applied, the amount of disease occurring in commercial fields has been very materially reduced. The average for five years in New Brunswick and Prince Edward Island is approximately three-quarters of 1 per cent of the total disease recorded.*

CAUSE

Black leg is caused by one of the most minute parasitic organisms known as bacteria. Although the causative organism found in various countries in which the disease occurs shows slight differences and is given different names, recent researches have shown that they are all identical or at least very closely related. The name, *Bacillus phytophthora* (Frank) Appel is now commonly used to designate the causative organism of black leg. The specific names *solanisapruss* (Harrison), *atrosepticus* (van Hall) and *melanogenes* (Pethybridge and Murphy) are used by other authors, describing the same disease.

SYMPTOMS

A knowledge of the general symptoms of the disease as it appears in the field is of considerable importance, because certain control measures depend upon an accurate diagnosis of the trouble.

The disease frequently causes what are commonly termed "misses," which result from the fact that the parasite, under favourable conditions, may destroy the seed piece before it germinates, or the sprouts before they appear above ground (pl. 2, fig. 5).

Affected plants may appear early in July and continue to make their appearance until late in August. Diseased plants are somewhat stunted and quite conspicuous, even at a distance, by their pale green or yellow foliage. In severe cases the upper leaves may assume somewhat of a metallic lustre. There is furthermore a noticeable tendency for the upper leaves in particular to become dwarfed, stiff, and erect, while the margins of the leaflets are generally rolled upwards. This type of growth habit (pl. 1, fig. 1), gives the tops of

* This applies only to fields planted with certified seed, which proves that with reasonable care this disease may be almost entirely eliminated.

affected plants a narrowed or contracted appearance which readily distinguishes them from healthy ones. Affected vines are generally crisp, lacking the elasticity and softness which characterize normal ones. This is due to an increase in strongly lignified vascular tissue and a transformation of part or most of the parenchyma cells of the cortex and pith into sclereids or hard-walled cells. When the parasite invades the tuber bearing stolons, aerial tubers may be produced which preclude normal tuber development, owing to interference with the translocation of the starch to the underground tubers.*

The symptoms just described, though secondary, are as a general rule the first to appear above ground under normal conditions. The primary symptoms are most characteristic. These appear on the lower part of the stem both below and above ground. They are characterized by dark brown or black cankers involving the tissues at the base of the stem, which symptom gives the disease its name (pl. 1, fig. 2, 4). Under favourable circumstances the disease runs upwards in a streak and may ultimately involve the entire stalk. The canker may also develop laterally, which promptly results in a girdling of the stem, causing death of the vine. Diseased plants or stems ordinarily offer little resistance when one attempts pulling them up, and frequently they break when even slight force is applied. This is due to the weakened condition of the tissues of the diseased portion of the stem. On pulling up a diseased plant, an examination of the affected part of the stem will reveal that the outer or cortical tissues are soft, or perhaps entirely decomposed, and the pith blackened or destroyed. When the pith entirely disintegrates it leaves the stem more or less hollow, where larvae of insects will occasionally be found feeding on the dead pith cells. The outer tissues when first involved remain more or less colourless, but ultimately they become quite blackened. The seed piece usually disintegrates (pl. 1, fig. 2). When the vines are destroyed death of the roots almost invariably follows. Lateral spread of the disease in large stems is comparatively slight. The stalk of the plant may in certain instances be severely diseased, yet such a plant may persist and mature a crop of tubers.

When the canker has progressed sufficiently to cut off completely the water supply in the stock the entire plant becomes brown and ultimately succumbs to the disease (pl. 1, fig. 3). If the disease develops early this will occur before any new tubers are produced. When late infection takes place the newly formed tubers may become affected, a number of which, unfortunately, are frequently carried into storage along with healthy ones. The skin of affected tubers presents a gun-metal appearance over the portions involved (pl. 2, fig. 1). Under moist conditions young tubers will rot very quickly and completely, but under dry conditions the rotted portions shrink and give the tubers a lopped-off appearance, and the progress of the rot is temporarily checked until more favourable conditions return. When the parasite invades the tuber-bearing stolons it passes along these structures until the stem end of the tuber is reached, where a dark area appears which may extend to a soft rotted condition further within the tuber (pl. 2, fig. 2, 4, 7). As a rule, stem-end infection of the tubers is most frequent under ordinary circumstances, but the causative organism may also gain entrance through wounds in other parts of the tuber and produce the disease (pl. 2, fig. 3).

Infection of the tuber may be confined on occasions to a brown discolouration in the tissues associated with the vascular elements (pl. 2, fig. 6) at the stem end, or it may involve the whole tuber, in which case the rot developing invariably destroys it. The decay associated with this disease is of the "soft rot" type in which the colour of affected tissues ranges from nearly normal to brown and black. Upon exposure to the air these portions rapidly become dark

* Rhizoctonia, a fungous disease, when similarly slightly girdling the tissues of the stolons, also often results, and for the same reason, in the production of aerial tubers.

brown and even black (pl. 2, fig. 8). Frequently a putrid odour accompanies the rot but this is not due to the disease primarily, but to rot-producing organisms following the black leg parasite. These secondary rot-producing organisms complete the process of decomposition of the tuber.

SPREAD OF THE DISEASE

When late infection occurs, or the disease does not advance rapidly, the newly formed tubers may show no evidence of infection at harvesting time. Nevertheless, they frequently harbour the black leg organism and, when placed in storage, may rapidly decay. Thus, healthy tubers coming in contact with decaying ones are also exposed to infection, and under favourable circumstances, a large percentage of tubers in a bin may be destroyed in this way. Those tubers which are only slightly affected or harbour the causative organism in a dormant state, may, if planted, give rise to diseased plants. The causative organism of the disease does not over-winter in the soil, though diseased tubers which occasionally survive the winter in the soil may produce diseased plants the following season.

While black leg is largely propagated by the use of diseased seed it is also disseminated by an insect known as the seed-corn maggot (*Phorbia fusiceps* Zett.) which feeds on certain vegetables commonly grown in Canada, particularly peas, beans, corn, and potatoes. The important discovery by Leach in Minnesota which revealed that the seed-corn maggot is capable of transmitting the disease, admirably explained the cause of sporadic outbreaks of black leg in fields where even healthy seed (carefully treated with standard disinfectants for the control of tuber-borne diseases) was used. The organism causing black leg appears to be closely associated with this insect and, extraordinarily, the latter thrives best when in company with this particular species of bacterium. The black leg organism is capable of passing through the larval, pupal, and adult stage of the insect in a virulent state. These organisms are commonly present in the intestinal tract of the adult stage of the insect, which is a fly (pl. 3, fig. 1). The adult fly lays its eggs upon or near the seed pieces. These eggs are covered with a sticky fluid which enables them to adhere to soil particles or other objects (pl. 3, fig. 2). The eggs hatch in about three days after they are deposited. From these eggs a maggot (larval stage), which is only slightly longer than the egg and almost transparent, emerges (pl. 3, fig. 3). This maggot is apparently not capable of boring its way into the tuber immediately, but allows the black leg organism which is in contact with it, to first destroy the skin or cortical tissues, by which means it may gain a readier entrance to the internal regions of the tuber. In this way the maggot incidentally inoculates the seed piece with the black leg organism which, after once being introduced, proceeds upon its mission of destruction. The maggot, after feeding on the flesh of the tuber for fifteen to twenty-five days, reaches maturity and then emerges from the seed piece and pupates in the adjacent soil (pl. 3, fig. 4). Pupation begins about a month after the potatoes are planted and is frequently under way when the first symptoms of black leg are evident. After remaining in the pupal stage for one or two weeks, the adult fly emerges and lays its eggs in or on the soil near the growing plants. These eggs in due time give rise to another brood of maggots capable of inoculating potato plants with the black leg organism. In this case the maggot usually introduces the parasite into that part of the stem nearest the ground, producing the late type of infection previously referred to. This late infection is of most serious consequence, for it is from plants so affected that many of the tubers which transmit

the disease originate. The seed-corn maggot has been observed in Canada and is doubtless responsible in considerable measure for sporadic outbreaks of black leg and late infection, in particular.*

The disease may also be transmitted to healthy tubers by using cutting knives which previously came in contact with diseased tubers.

During wet seasons before harvest the parasite may enter the tuber through the lenticels from contaminated soil and cause an extensive rotting.

PREDISPOSING CONDITIONS

Black leg is essentially a cool climate disease. In the Maritime Provinces it appears to develop most favourably under moist weather conditions. Hot, dry conditions preclude its occurrence. This disease is usually more severe in low, wet areas, but may also develop on well-drained soils if temperature and humidity conditions are favourable. Warm, moist, poorly ventilated storage conditions are also conducive to the development of the disease.

CONTROL MEASURES

(1) One of the first essentials in the control of black leg is the use of healthy seed. Tubers which are the progeny of affected plants, regardless of how sound they may appear, should be avoided when selecting potatoes for seed purposes. The exclusive use of Dominion Certified seed potatoes will reduce possibilities of the occurrence of this disease to a minimum.

(2) Avoid using seed from a field in which a large amount of black leg has occurred.

(3) When selecting tubers for seed purposes eliminate those showing the least evidence of decay or discoloration.

(4) Always sterilize the cutting knife in a formalin solution, consisting of one-half ounce of chemical to a gallon of water, after a tuber which shows traces of rot has been cut and before using the same knife on a healthy tuber.

(5) All tubers intended for seed purposes should be disinfected in either of the following:—

- (a) A solution of formalin (1 pint to 30 gallons of water) for 2 hours.
- (b) A solution of bichloride of mercury, commonly called corrosive sublimate, (4 ounces to 25 gallons of water) for $1\frac{1}{2}$ hours. Owing to the fact that this chemical rapidly deteriorates when brought into contact with soil and potatoes, the solution should be completely renewed after every fourth lot of tubers is treated. Use a wooden or earthenware container for the solution, because a metal one weakens its disinfecting powers. Corrosive sublimate is a deadly poison, consequently, treated seed should not be used for feeding purposes.

Potato tubers should be soaked in clean water for 6 to 10 hours prior to treatment in order to remove adhering particles of soil and dirt which interfere with the process of disinfection.

(6) Avoid planting potatoes too early into a cold soil and especially in an improperly drained soil, for a wet soil favours the disease.

(7) As far as is practicable all diseased plants should be removed from the field and destroyed as soon as they are observed. Make certain that all tubers attached to such plants are also destroyed. Undersized vines with more or less yellowed and rolled leaves should be regarded with suspicion and more closely examined for the presence of the black cankers on the stem both above and below ground.

* The paragraph dealing with the seed-corn maggot has been kindly approved by the Dominion Entomologist.

(8) Tubers from plants affected with black leg, even although they may appear perfectly sound, should not be stored with healthy ones. Tubers showing any trace of the disease should not be placed in storage. The storage house should be maintained as cool, dry, and well ventilated as possible.

(9) Cut seed should be planted immediately in order to minimize opportunities for the seed-corn maggot to lay its eggs on the seed pieces. Seed which has been exposed for some time in the field frequently shows a higher percentage of black leg for this reason.

(10) Providing the potato crop is intended for seed purposes, arrange to have the same inspected by the Dominion seed potato inspectors, who will communicate timely information relative to the control of this and other serious diseases commonly occurring.

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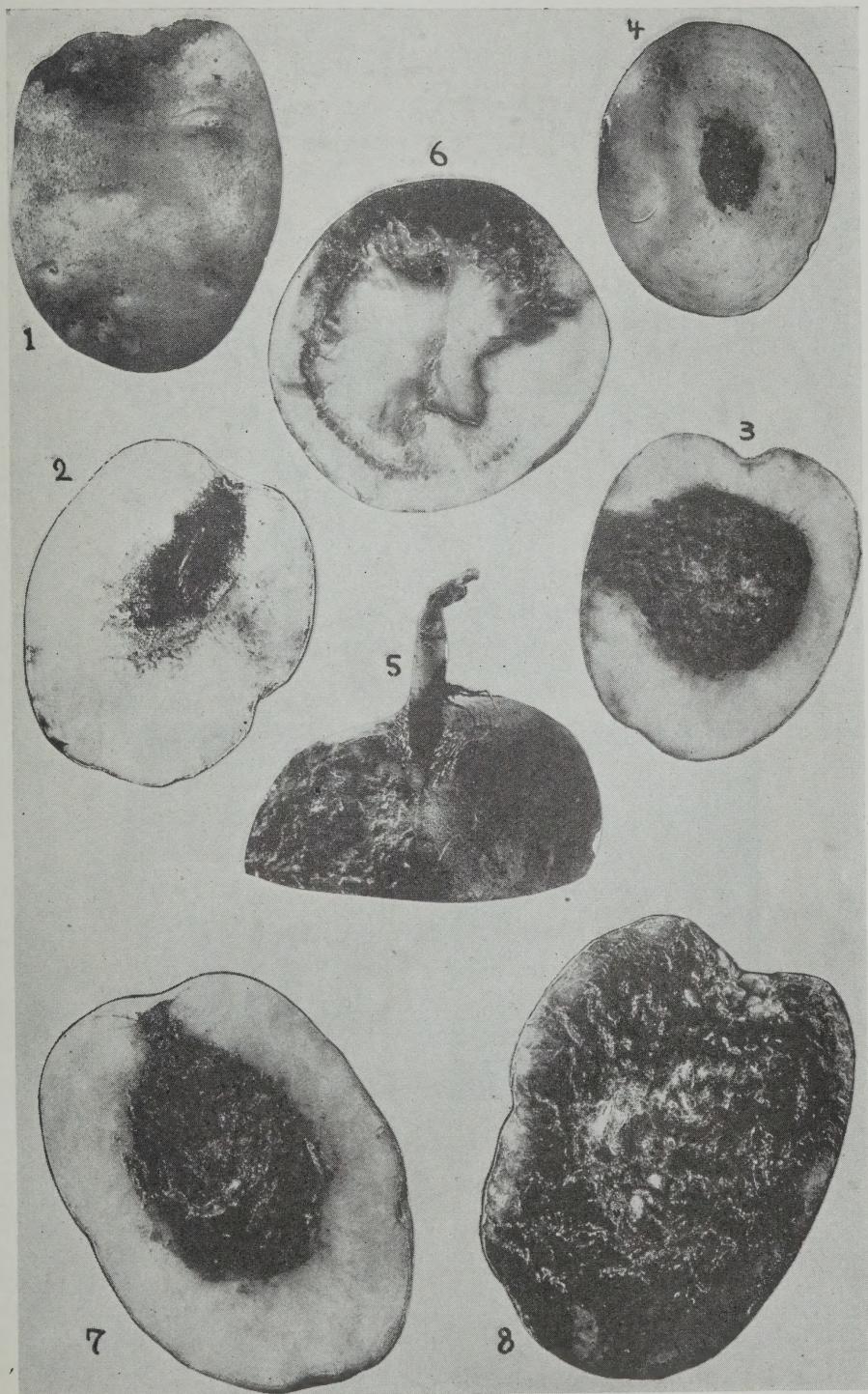
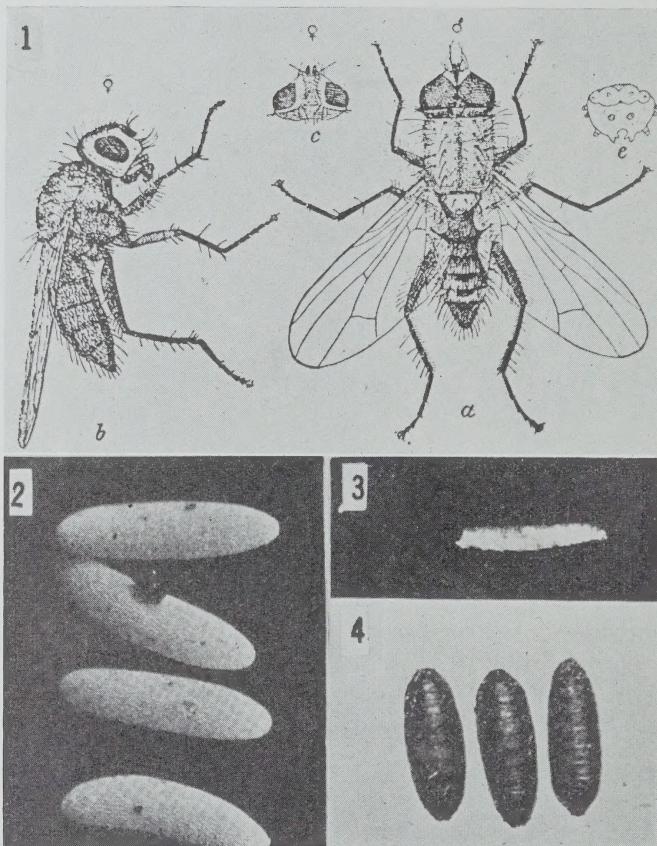


PLATE 3.



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